COMPUTER HAVING COOLING APPARATUS AND HEAT EXCHANGING DEVICE OF THE COOLING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of U.S. Patent No. 09/572,282, filed on May 25, 2000, which is herein incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a computer having a cooling apparatus and a heat exchanging device of the cooling apparatus, and more particularly, to a computer having a cooling apparatus having an improved cooling capacity and configured to prevent contamination due to flow of ambient air, and a heat exchanging device used for the cooling apparatus.

2. Description of the Related Art

It is known well that electronic devices including computers generally have heat-producing components. Various types of cooling systems have been proposed for removing heat from the heat-producing components to maintain the electronic device within operating temperature limits. Although there are various devices including hydrocooling systems, air cooling systems and systems that employ gaseous and liquid coolants, the most typically used systems are forced air cooling systems using fans.

However, the conventional apparatuses have many drawbacks. One of the drawbacks is lack of cooling capacity. Recently, according to rapid development of electronics industry, components of the electronic devices have become highly integrated and heat-producing densities are also increasing. Accordingly, existing air cooling systems have limitations in solving problem of heat production in spite of continued improvement of cooling fan performance. Also, efforts to increase cooling capacity result in bulkiness and complexity of cooling systems.

In addition to the insufficient cooling capacity, another drawback of the conventional air cooling systems includes noise due to use of fans. As the modern society becomes advanced, the working conditions of people are inseparable from computers or various electronic devices and people are getting highly sensitive to

ambient noise. Therefore, it is important to offer quiet working surroundings to people who concentrate on various kinds of business in a closed working space.

A third problem is contamination of a computer, caused by a fan for inducing air flow to cool heat-producing components of a computer or components of a cooling apparatus, e.g., radiators. Use of a fan for dissipating the heat generated inside a computer may cause external air, dust or other contaminants to be induced inside the computer. The induced dust or other contaminants may contaminate electronic components to cause damage thereto, and may be collected inside the computer to obstruct air flow, resulting in deteriorated cooling efficiency.

Nevertheless, expensive industrial computers operating under inferior working conditions cannot be isolated from working spaces because of cooling, so that they are forcibly exposed to the inferior working conditions. Thus, the life spans of the expensive computers may be shortened or defects thereof may increase.

SUMMARY OF THE INVENTION

To solve the above problems encountered with the prior art, it is an object of the present invention to provide a computer having a cooling apparatus which has improved cooling capacity and in which a fan and heat radiating fins are isolated from heat-producing components to prevent contamination due to flow of ambient air, and a heat exchanging device used in the cooling apparatus for cooling the heat-producing components.

The present invention provides a computer having a housing defining an interior space and at least one heat-producing components installed inside the housing, the computer comprising a cooling apparatus for cooling the heat-producing components.

The computer according to the present invention includes a heat exchanging device in heat exchangeably contact with the heat-producing component and having a passageway extending between an inlet port and an outlet port, a heat dissipation device having a reservoir for storing a liquid coolant having an inlet opening and an outlet opening spaced a predetermined distance apart from the inlet opening, and a plurality of radiating fins installed on the outer surface of the reservoir so as to be capable of exchanging heat with the reservoir, a first conduit extending between the outlet port of the heat exchanging device and the inlet opening of the reservoir, a

second conduit extending between the outlet opening of the reservoir and the inlet port of the heat exchanging device, a pump for pumping the liquid coolant out of the reservoir through the outlet opening, through the second conduit, the passageway and the first conduit, and back into the reservoir through the inlet opening, and a separating wall separating the heat dissipation device from the interior space to isolate the heat-producing component from the flow of ambient air

The cooling apparatus provided in the computer according to the present invention can be used in various types of computers. In the first embodiment of the present invention, the cooling apparatus is used in a personal computer having a tower case. The heat dissipation device is mounted inside a subhousing installed on the bottom wall of the tower case. The heat dissipation device may be installed in the interior space formed between either the bottom wall or the side wall of the tower case and the separating wall by the separating wall installed inside the tower case.

In the second embodiment of the present invention, the computer is used in an industrial computer having a housing in the form of a rack mounting case. In the side wall of the case, an inlet vent and an outlet vent are formed at side walls of the case to be spaced apart from each other, and the opposite ends of the heat dissipation device are positioned adjacent to the inlet vent and the outlet vent. This arrangement of the inlet and outlet vents can prevent the flow of air from being shielded by adjacent computers installed on racks stacked in multiple layers.

Also, the cooling apparatus provided in the computer according to the present invention may further include a fan. The fan is disposed adjacent to one end of the heat dissipation device and in communication with ambient air, and compels the ambient air to flow through the radiating fins to exhaust the heat from the liquid coolant stored in the reservoir, the fan being isolated from the interior space by the separating wall.

Alternatively, the present invention also provides heat exchanging devices for cooling heat-producing components of a computer. The heat-producing components have various types and the heat exchanging devices also have various types accordingly. In other words, the heat exchanging devices used to cool a power supply, a hard drive, a CPUI and a memory have configurations and types corresponding to each type.

The present invention provides a cooling apparatus which can overcome

drawbacks of the conventional cooling apparatus and can cool heat-producing components thereof effectively and reliably and a computer including the cooling apparatus. According to the present invention, while protecting the heat-producing components from contamination due to flow of and contact with ambient air, the heat-producing components can be effectively cooled by a water-cooling method using a cooling liquid.

In order to dissipate heat from the cooling liquid, the flow of ambient air passing through heat-radiating fins may be formed by natural convection or may be forcibly formed by a fan. The fan provided in the cooling apparatus can be controlled to operate with rated power or below. Even if the fan is operated with the rated power or below, it is designed to have a sufficient cooling capacity. If the fan is operated with the rated power or below, e.g., with 70% of the rated power, only a small amount of noise is generated, compared with the case when the fan is operated at 100% of the rated power. This level of noise is barely perceptible under ordinary office circumstances, providing agreeable working surroundings. Also, if the fan is operated with 70% of the rated power, the life span of the fan is greatly prolonged, thereby reducing the generation of objectionable noise due to wear of the fan and extending the replacement cycle of the fan. However, in hot summer or under extremely inferior circumstances, in order to maximize the cooling capacity, the fan may be operated with full rated power. To this end, a temperature sensor may be provided. The temperature sensor can automatically control the speed of the fan according to the temperature of heat-producing components.

The apparatuses according to the present invention are relatively simplified and can be standardized in view of type and size so as to be easily applied to various types of computers.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIGS. 1A and 1B are perspective views of the outer appearance a personal computer having a cooling apparatus according to a first embodiment of the present invention, respectively viewed front and rear sides thereof;

FIG. 2 is a schematic diagram of the structure of the cooling apparatus shown

in FIGS 1A and 1B;

FIGS. 3A through 3C are partly cut-away perspective views of a personal computer in which a heat dissipation device is provided inside a tower case, viewed from a front side thereof, unlike in FIGS. 1A and 1B;

FIG. 4A is a perspective view of the outer appearance of a heat dissipation device shown in FIG. 2, FIG. 4B is a cross-sectional view of the heat dissipation device shown in FIG. 4A, taken along line A-A, and FIG. 4C is a cross-sectional view of the heat dissipation device shown in FIG. 4A, taken along line B-B;

FIGS. 5A and 5B are a partly cut-away perspective view and an elevational view of a heat exchanging device according to an embodiment of the present invention for use in a power supply, respectively;

FIG. 6 is a partially exploded perspective view of a heat exchanging device according to another embodiment of the present invention for use in a power supply;

FIG. 7A is a partly cross-sectioned elevational view of a heat exchanging device according to still another embodiment of the present invention for use in a power supply, and FIG. 7B is a partly cut-away perspective view of a heat exchanging device according to still yet another embodiment of the present invention for use in a power supply;

FIG. 8 is an exploded perspective view of a heat exchanging device according to an embodiment of the present invention for use in a hard drive;

FIG. 9 is an exploded perspective view of a heat exchanging device according to another embodiment of the present invention for use in a hard drive;

FIG. 10 is a perspective view showing a state in which the heat exchanging device shown in FIG. 9 is installed in the hard drive;

FIG. 11 is an exploded perspective view of a heat exchanging device according to an embodiment of the present invention for use in a CPU;

FIG. 12 is a partially cross-sectional elevational view of the heat exchanging device shown in FIG. 11;

FIG. 13 is an exploded perspective view of a means for securely contacting the heat exchanging device shown in FIG. 11 with a CPU;

FIGS. 14A and 14B are a perspective view and a partially cross-sectional view showing the connected state of the securely contacting means shown in FIG. 13;

FIG. 15 is an exploded perspective view of a heat exchanging device

according to another means for securely contacting the heat exchanging device shown in FIG. 11 with a CPU;

FIGS. 16A and 16B are a perspective view and a partially cross-sectional view showing the connected state of the securely contacting means shown in FIG. 15;

FIG. 17 is an exploded perspective view of a heat exchanging device according to an embodiment of the present invention for use in a memory;

FIG. 18 is a perspective view showing a state in which the heat exchanging device shown in FIG. 17 is installed in the memory;

FIG. 19 is a perspective view of an industrial computer having a cooling apparatus according to another embodiment of the present invention;

FIG. 20 is a perspective view of an industrial computer having a cooling apparatus installed in a direction different from that of FIG. 19;

FIG. 21 is a partly cut-away perspective view of a personal computer having a cooling apparatus according to still another embodiment of the present invention;

FIG. 22 is a schematic diagram of the structure of the cooling apparatus installed in the personal computer shown in FIG. 21; and

FIG. 23 is a fragmentary perspective view of a personal computer having a cooling apparatus according to still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiment of the present invention will now be described in more detail with reference to the accompanying drawings.

FIGS. 1A and 1B are perspective views of a personal computer having a cooling apparatus according to a first embodiment of the present invention, respectively viewed front and rear sides thereof, and FIG. 2 is a schematic diagram of the structure of the cooling apparatus shown in FIGS 1A and 1B.

First, referring to FIGS. 1A and 1B, a personal computer 2 has a housing in the form of a tower case 4. The tower case 4 includes a front 8, an opposite back 10 and a bottom wall 12. A subhousing 14 is installed on the bottom wall 12 of the tower case 4. The subhousing 14 itself has a bottom wall 16. Air inlet vents 18 are formed on the front end of the subhousing 14, and air outlet vents 20 are formed in the opposite rear end. Arrows shown in FIGS. 1A and 1B indicate the directions of the flow of air.

Referring to FIG. 2, the tower case 4 defines an interior space 6 of the personal computer 2. A plurality of components are installed in the interior space 6, that is, inside the tower case 4. These components are of various types and include a plurality of heat-producing components. The components installed inside the tower case 4 include a power supply 22 and a hard drive 24. A mother board 26 is also installed inside the tower case 4. In general, a plurality of components are installed in the mother board 26. In FIG. 2, three components are installed in the mother board 26. These components are a CPU 28, a microprocessor chip 30 and a memory 32. These three components 28, 30 and 32, the power supply 22 and the hard drive 24 are heat-producing components. Thus, as will be described below, a cooling apparatus for cooling these components is necessary.

In accordance with the present invention, a heat exchanging device having a passageway connected between an inlet and an outlet is installed in each heat-producing component. The passageway heat-exchangeably contacts with the heat-producing components. Liquid coolant C circulates through the passageway to carry heat away from the components.

The cooling apparatus also includes a heat dissipation device 36. The heat dissipation device 36 is mounted in the subhousing 14 and has a reservoir 38 for storing the liquid coolant C. The reservoir 38 is preferably made from a heat conductive material, for example, aluminum. The reservoir 38 has an inlet opening 40 and an outlet opening 42 spaced from the inlet opening 40. A plurality of radiating fins 44 are mounted on the outer surface of the reservoir 38. The radiating fins 44 are in heat exchangeable contact with the outer surface of the reservoir 38. The radiating fins 44 can be integrally formed with or separately formed from the reservoir 38. The liquid coolant C circulates from the reservoir 38 to the heat exchanging device on the heat-producing components and back to the reservoir 38. A first conduit 46 extends from the outlet port of the heat exchanging device to the inlet opening 40 of the reservoir 38. A second conduit 48 extends from the outlet opening 42 and the inlet port of the heat exchanging device. As shown, the liquid coolant C circulates through the passageways of the various heat exchanging devices for the heat-producing components in series. The liquid coolant C moves from the reservoir 38 to the inside of the heat exchanging device for the hard drive 24 through the second conduit 48 and then moves from the heat exchanging device for the hard drive 24 to the heat exchanging device for the power supply 22. From

the power supply 22, the coolant C circulates consecutively through the heat exchanging devices for the memory 32, the microprocessor chip 30 and the CPU 28. From the outlet port of the heat exchanging device for the CPU 28, the coolant C circulates back via the first conduit 46 to the reservoir 38 through the inlet opening 40. Small arrows shown in FIG. 2 indicate circulation paths of the coolant C. Although the circulation paths of the coolant C are disposed in series in FIG. 2, they may be disposed in parallel or in combination of parallel and series arrangements according to the heat transfer amount of the heat-producing components and installation locations thereof. A pump 52 for circulating the coolant C is installed inside the reservoir 38, as described above.

The important feature of the present invention lies in that the heat-producing components installed in the space 6 are isolated from the flow of ambient air. To provide such isolation, one or more separating walls for separating the heat dissipation device 36 from the interior space 6 are provided. In the embodiment shown in FIGS. 1A and 1B and FIG. 2, the bottom wall 12 of the tower case 4 functions as the separating wall.

The cooling apparatus may further include a fan 50 installed in the subhousing 14. The fan 50 is positioned adjacent to an end of the heat dissipation device 36 and is in communication with ambient air through the air outlet vent 20 of the subhousing 14. The fan 50 operates to direct ambient air through the radiating fins 44 to dissipate heat from the liquid coolant C in the reservoir 38. The fan 50 is also separated from the interior space 6 by the separating wall. Large arrows shown in FIG. 2 indicate the directions of the flow of ambient air. FIGS. 3A through 3C show a personal computer having a heat dissipation device provided inside a tower case, unlike in FIGS. 1A and 1B. FIG. 3A illustrates an embodiment in which a heat dissipation device is installed adjacent to the bottom of a tower case, and FIGS. 3B and 3C illustrate embodiments in which heat dissipation devices are installed on the side s of a tower case. Arrows shown in FIGS. 3A through 3C indicate the directions of the flow of ambient air.

Referring to FIG. 3A, a separating wall 315 is installed inside a tower case 304 of a personal computer 302 to be spaced apart from a bottom wall 312 of the tower case 304. The heat dissipation device 36 is installed between the bottom wall 312 and the separating wall 315. Also, the fan 50 may be installed adjacent to one end of the heat dissipation device 36. An inlet vent 318 is provided adjacent to the

other end of the dissipation device 36 in the lower portion of a front 308 of the tower case 304. Also, an outlet vent (not shown) is provided adjacent to the fan 50 in the lower portion of the rear of the tower case 304. In other words, the separating wall 315 is installed between the heat-producing components installed inside the interior space 306 and the heat dissipation device 36. Thus, the heat-producing components can be isolated from the flow of ambient air by the separating wall 315. Referring to FIG. 3B, a separating wall 415 is installed inside a tower case 404 of a personal computer 402 to be spaced apart from a side wall 409 of the tower case 404. The heat dissipation device 36 is installed between the side wall 409 and the separating wall 415. Also, the fan 50 may be installed adjacent to one end of the heat dissipation device 36. An inlet vent 418 is provided adjacent to the other end of the heat dissipation device 36 on the side wall 409 of the tower case 304. Also, an outlet vent (not shown) is provided adjacent to the fan 50 in the back of the tower case 304. The radiating fins 44 of the heat dissipation device 36 are preferably horizontally installed along the direction of the flow of ambient air. Thus, the heat-producing components installed in the interior space 406 can be isolated from the heat dissipation device 36 and the fan 50 by the separating wall 415.

Referring to FIG. 3C, a separating wall 515 is installed inside a tower case 504 of a personal computer 502 to be spaced apart from a side wall 509 of the tower case 504. The heat dissipation device 36 is installed between the side wall 509 and the separating wall 515. An inlet vent 518 is provided adjacent to one end of the heat dissipation device 36 in the lower portion of the side wall 509. Also, an outlet vent 520 is provided adjacent to the other end of the dissipation device 36 in the upper portion of the side wall 509. The radiating fins 44 of the heating dissipation device 36 are preferably vertically installed along the direction of the flow of ambient air. Thus, the heat-producing components installed in the interior space 506 of the tower case 504 can be isolated from the flow of ambient air by the separating wall 515. In this embodiment, a fan is not installed, unlike the above-described embodiments. Thus, the flow of ambient air passing through the heat transfer fin s 44 is produced by natural convection. To this end, as described above, the inlet vent 518 and the outlet vent 520 are disposed in the lower and upper portions of the side wall 509, respectively. The air induced through the inlet vent 518 provided in the lower portion of the side wall 509 becomes warmer while passing through the radiating fins 44, the warm air is elevated to then be exhausted to the outside

through the outlet vent 520 provided in the upper portion of the side wall 509. If the flow of ambient air is produced by natural convection rather than a fan, as described above, noise due to the use of the fan is not generated.

The heat dissipation device 36 will now be described in more detail with reference to FIGS. 4A, 4B and 4C. Referring thereto, the heat dissipation device 36 has the reservoir 38 for storing the liquid coolant C. The radiating fins 44 are installed on the outer surface of the reservoir 38. The fan 50 is disposed adjacent to one end of the heat dissipation device 36, and a pump 52 for circulating the liquid coolant C is installed inside the reservoir 38. An outlet opening 42 and an inlet opening 40 for exhausting and recovering the liquid coolant C, are provided on the top portion of the reservoir 38. Also, an opening for refilling/exhausting the liquid coolant C into/from the reservoir 38, is provided at one side of the reservoir 38, and a thread 37 is tightened with the opening.

One or more divider walls 49 are installed inside the reservoir 38. A selected divider wall 49 extends from one-end inner wall of the reservoir 38 and the end thereof is spaced from the other-end inner wall of the reservoir 38. The direction of the flow of the liquid coolant C is inverted through the space between the end of the selected divider wall 49 and the other-end inner wall of the reservoir 38. Another divider wall adjacent to the selected divider wall 49 extends from the other-end inner wall of the reservoir 38. As described above, the divider wall 49 elongates the path of the flow of the liquid coolant C back into the reservoir 38 so that heat transfer from the liquid coolant C is sufficiently performed through the radiating fins 44. Arrows shown in FIG. 4C indicate the direction of the flow of the liquid coolant C.

FIG. 5A and 5B illustrate preferred embodiments of heat exchanging devices for use in a power supply. Referring to FIGS. 5A and 5B, a heat exchanging device according to this embodiment includes a heat sink 58 made of aluminum. The heat sink 58 may be integrally formed by a die-casting method. The heat sink 58 is mounted on a board 59. The power supply 22 includes a plurality of heat-producing elements 60 and 61. These elements 60 and 61 are, for example, a transistor and/or a transformer. The elements 60 and 61are mounted on the heat sink 58 and are in heat exchangeable contact with the heat sink 58. A channel 62 is provided at each side of the heat sink 58. The pair of channels 62 are parallel to each other. A U-shaped conduit 64 is fitted into the channel 62 and heat-exchangeably contacts with the heat sink 58. To this end, a heat bond is preferably interposed between the

inner surface of the channel 62 and the outer surface of the U-shaped conduit 64. The opposite ends of the U-shaped conduit 64 form an inlet port 66 and an outlet port 68 of the heat exchanging device. The U-shaped conduit 64 functions as a circulation passageway of the liquid coolant of the heat exchanging device according to this embodiment. The liquid coolant circulating through the passageway carries away heat from the heat sink 58 to then be exhausted. Thus, the heat generated from the elements 60 and 61 is exhausted.

FIG. 6 illustrates another embodiment of a heat exchanging device for use in a power supply. Referring to FIG. 6, the heat exchanging device according to this embodiment includes a heat sink 58' made of aluminum. The heat sink 58' is divided into two parts. A heat pad 65 for preventing leakage and transferring heat, is inserted between the two parts and assembled. The power supply 22 includes a plurality of heat-producing elements 60 and 61. The elements 60 and 61 are mounted on the heat sink 58'. Of the elements 60 and 61, the element 61 installed in the middle of the heat sink 58', for example, a transformer, is in heat exchangeably contact with the heat sink 58' by a silicon heat bond material. Also, the element 60 installed at the lateral side of the heat sink 58', for example, a transistor, is in heat exchangeably contact with the heat sink 58'. An interior passageway 63 through which the liquid coolant passes, is formed inside the heat sink 58'. Short conduits 69 and 70 are fitted into the opposite ends of the interior passageway 63 to form an inlet port 66' and an outlet port 68' through which the liquid coolant comes in and goes out, respectively. The interior passageway 63 functions as the liquid coolant circulating passageway of the heat exchanging device according to this embodiment. The heat generated from the elements 60 and 61 is collected at the heat sink 58' and is transferred to the liquid coolant circulating through the interior passageway 63 to then be exhausted outside the heat dissipation device.

As described above, the heat exchanging devices shown in FIGS. 5A and 5B and FIG. 6 adopt a cooling method in which the heat generated from the heat-producing elements 60 and 61 of the power supply 22 is collected at aluminum heat sinks 58 and 58' to then be exhausted, that is, cooled at a time, rather than cooled separately, thereby improving the cooling capacity and simplifying the configuration.

FIG. 7 shows still another embodiment of a heat exchanging device for use in a power supply. Referring to FIG. 7A, the heat exchanging device according to this

embodiment includes a hermetic container 210 installed to surround the power supply 22. A liquid coolant C' contained in the hermetic container 210. The liquid coolant C' is in direct contact with the power supply 22 so as to be capable of exchanging heat. Thus, in this embodiment, an insulating oil is used as the liquid coolant C' circulating between the heat dissipation device and the heat exchanging device for insulation between the liquid coolant C' and the power supply 22. A coolant refilling opening 211 and a cap 212, for refilling the liquid coolant C', that is, the insulating oil, are provided on the top portion of the hermetic container 210. An inlet port 216 and an outlet port 218 through which the liquid coolant C' comes in and goes out, are formed on the side wall of the hermetic container 210. Preferably, the inlet port 216 is formed at the lower portion of the side wall and the outlet port 218 is formed at the upper portion of the side wall. Thus, the liquid coolant C' which comes into the hermetic container 210 through the inlet port 216 gets warmer while contacting the power supply 22, and the warmed liquid coolant C' is elevated to then be exhausted through the outlet port 218. The circulation of the liquid coolant C' is more smoothly performed by thermal convection of the liquid coolant C'. Also, the inlet port 216 and the outlet port 218 may be disposed at opposite side walls of the hermetic container 210. As described above, according to this embodiment, the insulating oil is used as the liquid coolant C', which is in direct contact with the power supply 22, thereby insulating the power supply 22 and ensuring a cooling effect.

FIG. 7B shows still another embodiment of a heat exchanging device for use in a power supply. Referring to FIG. 7B, the heat exchanging device according to this embodiment includes a hermetic container 220 installed to surround the power supply 22, like in the embodiment shown in FIG. 7A. An insulating oil 223 is contained inside the hermetic container 220 as high as it contacts an upper wall of the hermetic container 220. The insulating oil 223 is in direct contact with the power supply 22 so as to be capable of exchanging heat. A cooling plate 230 heat-exchangeably contacts with the hermetic container 220 at its outer top surface. A silicon heat pad 225 having a high heat conductivity may be inserted between the cooling plate 230 and the outer top surface of the hermetic container 220. A long, U-shaped channel 232 is provided on the bottom surface of the cooling plate 230. A U-shaped conduit 234 is fitted into the channel 232 and heat-exchangeably contacts with the cooling plate 230. To this end, a heat bond may be interposed between the inner surface of the channel 232 and the outer surface of the U-shaped

conduit 234. The bottom of the U-shaped conduit 234 is formed flatly so as to be securely in contact with the outer top surface of the hermetic container 220. The opposite ends of the U-shaped conduit 234 form an inlet port 236 and an outlet port 238 of the heat exchanging device. The U-shaped conduit 234 functions as a liquid coolant circulating passageway of the heat exchanging device according to this embodiment. As described above, the insulating oil 223 of this embodiment is not used as the liquid coolant circulating between the heat dissipation device and the heat exchanging device, unlike the embodiment shown in FIG. 7A. The insulating oil 223 of this embodiment absorbs heat generated from the power supply 22 and transfers the same to the liquid coolant flowing through the passageway formed in the cooling plate 230 securely in contact with the outer top surface of the hermetic container 220. In other words, the heat generated from the power supply 22 is absorbed by the insulating oil 223 and the warmed insulating oil 223 is elevated by thermal convection. Then, the heat is transferred to the cooling plate 230 through the upper wall of the hermetic container 220 and the heat pad 225. The thus-transferred heat is then transferred to the liquid coolant flowing through the U-shaped conduit 234 installed in the cooling plate 230, thereby cooling the power supply 22. According to this embodiment, the power supply 22 can be more effectively cooled while more securely insulating the power supply 22.

FIGS. 8 through 10 illustrate two embodiments of heat exchanging devices for use in a hard drive. Recently, hard drives have rapidly developed in their performance, and in particular, high-speed revolution thereof have noticeably progressed. Accordingly, the amount of heat produced has also increased more severely. Heat-producing portions of a hard drive are mainly rotary portions or a microprocessor portion. In particular, the rise in the temperature is the most severe at the rotary portions.

The heat exchanging device shown in FIG. 8 can be used for cooling a general hard drive 24 mounted in a computer. As shown, the heat exchanging device of this embodiment includes a cooling plate 126 in heat exchangeably contact with the bottom surface of the hard drive 24. Two parallel channels 127 are spaced apart from each other on one surface of the cooling plate 126, that is, a surface in heat exchangeably contact with the bottom surface of the hard drive 24 for heat exchange. A U-shaped conduit 128 is fitted into the channels 127 and heat-exchangeably contacts with the cooling plate 126. To this end, a heat bond

may be interposed between the inner surface of the channels 127 and the outer surface of the U-shaped conduit 128. The opposite ends of the U-shaped conduit 128 form an inlet port 129 and an outlet port 130 of the heat exchanging device. The top surface of the U-shaped conduit 128 is formed flatly so as to be securely in contact with the bottom surface of the hard drive 24. The U-shaped conduit 128 functions as the liquid coolant circulating passageway of the heat exchanging device according to this embodiment. Also, a silicon heat pad 124 having high heat conductivity may be inserted between the cooling plate 126 and the bottom surface of the hard drive 24. The heat pad 124 allows the heat produced from the hard drive 24 to be easily transferred to the cooling plate 126. Thus, the heat produced at the hard drive 24 is transferred to the cooling plate 126 through the heat pad 124 and then transferred to the liquid coolant flowing through the U-shaped conduit 128 installed in the cooling plate 126, thereby cooling the hard drive 24.

Heat exchanging devices shown in FIGS. 9 and 10 can be used for cooling the hard drive 24 capable of swapping to be installed in a computer so as to be replaceable. Referring to FIG. 9, the heat exchanging device of this embodiment includes a heat collecting plate 152 in heat exchangeably contact with the bottom surface of the hard drive 24 so as to be capable of exchange heat. The heat collecting plate 152 is preferably formed of a material having high heat conductivity, e.g., copper. A silicon heat pad 154 having a high heat conductivity is inserted between the heat collecting plate 152 and the bottom surface of the hard drive 24 to allow the heat generated at the hard drive 24 to be easily transferred to the heat collecting plate 152. The hard drive 24 and the heat collecting plate 152 can be securely combined by thread holes 155 and 155' provided at the respective lateral surfaces and tightening threads 158 tightened with the thread holes 155 and 155'. A handle 153 for facilitating replacement of the hard drive 24 is provided at one end of the heat collecting plate 152. The heat exchanging device includes a cooling plate 156 in heat exchangeably contact with the bottom surface of the heat collecting plate 152. A long, U-shaped channel 157 is provided on the bottom surface of the cooling plate 156. A U-shaped conduit 148 is fitted into the channel 157 and heat-exchangeably contacts with the cooling plate 156. To this end, a heat bond may be interposed between the inner surface of the channel 157 and the outer surface of the U-shaped conduit 148. The opposite ends of the U-shaped conduit 148 form an inlet port 149 and an outlet port 150 of the heat exchanging device.

The U-shaped conduit 148 functions as a liquid coolant circulating passageway of the heat exchanging device according to this embodiment. As described above, the heat generated from the hard drive 24 is transferred to the heat collecting plate 152 through the heat pad 154 and then transferred to the liquid coolant flowing through the U-shaped conduit 148 installed in the cooling plate 156 securely in contact with the heat collecting plate 152, thereby cooling the hard drive 24.

Referring to FIG. 10, the cooling plate 156 is installed on the interior bottom of a slot 25 for mounting the hard drive 24 provided in a computer so as to be replaceable. Thus, if the combined structure of the hard drive 24 and the heat collecting plate 152 is fitted into the slot 25, the bottom surface of the heat collecting plate 152 is brought into heat exchangeably contact with the top surface of the cooling plate 156. Here, the handle 153 provided at the heat collecting plate 152 makes the combined structure of the hard drive 24 and the heat collecting plate 152 easily detachable from the slot 25. A plate spring 159 having one end fixed is installed on the slot 25. The plate spring 159 presses the top surface of the hard drive 24 by its elasticity when the combined structure is inserted into the slot 25, thereby making the bottom surface of the heat collecting plate 152 more securely contact with the top surface of the cooling plate 156. Thus, the heat conductivity between the heat collecting plate 152 and the cooling plate 156 is increased. The plate spring 159 is bent so as to increase the contact portions with the top surface of the hard drive 24, to achieve balancing at pressure.

FIGS. 11 and 12 illustrate preferred embodiments of heat exchanging devices for use in a CPU. As shown, the heat exchanging device 140 includes a cooling plate 131. A passageway 136 through which a liquid coolant passes is provided on the inner surface 132 of the cooling plate 131. An inlet port 138 and an outlet port 139 through which the liquid coolant comes in and goes out, are provided at the opposite ends of the passageway 136. The passageway 136 is formed by a rectangular recess formed on the inner surface 132 and divider walls 137 installed in the interior of the rectangular recess. The divider walls 137 extend across the rectangular recess about two-thirds of the way from one recess wall to an opposite recess wall. One or more divider walls may be installed. In the case where two or more divider walls 137 are installed, a divider wall adjacent to a selected divider wall extends from the opposite recess wall in order to make the passageway serpentine. The serpentine passageway 136 allows sufficient heat transfer by making the flow

path of the liquid coolant longer. A temperature sensor 142 for controlling the temperature of a CPU may be installed at one side of the cooling plate 131. The speed of the fan can be adjusted according to the temperature detected by the temperature sensor 142. Thus, when the temperature excessively rises, the system can be made to stop operating for safety and a warning message can be issued. Also, the temperature detected by the temperature sensor 142 can be displayed to be notified to a user.

The heat exchanging device 140 includes a bottom plate 134 having one surface being securely in contact with the inner surface 132 of the cooling plate 131 for hermetically sealing the liquid coolant. The bottom plate 134 is preferably formed of copper having a high heat conductivity. The other surface of the bottom plate 134 heat-exchangeably contacts with the surface of the CPU. Thread holes 133 and 133' are provided at four edges of the cooling plate 131 and the bottom plate 134, respectively, so that the cooling plate 131 and the bottom plate 134 are securely tightened with each other by tightening threads 135. Preferably, a heat pad 141 is inserted between the inner surface 132 of the cooling plate 131 and the bottom plate 134 along the periphery of the recess in order to prevent leakage and enhance the heat conductivity.

FIGS. 13 through 16B illustrate means for securely contacting heat exchanging devices according to the above-described embodiments with the surface of a CPU.

The means illustrated in FIGS. 13, 14A and 14B can be used for securely contacting the heat exchanging devices according to the above-described embodiments with a socket type CPU. As shown, projections 169 are provided on at least two facing lateral sides of a CPU socket 27 on which a CPU 28 is mounted. The securely contacting means used for the CPU 28 includes a crossed compression plate 160 installed on the cooling plate 131 and a fastening thread 166 for securely contacting the bottom plate 134 with the surface of the CPU 28 by pressing the top surface of the cooling plate 131. A thread hole 162 to which the fastening thread 166 is engaged is provided in the center of the compression plate 160. Two facing ends of the compression plate 160 are bent downward, and locking openings 164 locked with the projections 169 are formed at the bent ends. Locking openings 164, equal in number to the projections 169, here three, are preferably formed at each of the bent ends. Also, a thread center maintaining

groove 145 for maintaining the center of the fastening thread 166 is provided in the center on the cooling plate 131. An inlet port 138 and an outlet port 139 of the heat exchanging device 140 protrude upward on the cooling plate 131 in order to avoid interference with the compression plate 160. In a state in which the compression plate 160 is installed on the heat exchanging device 140 and the locking opening 164 is locked with the projection 169, the fastening thread 166 is fastened, the fastening thread 166 presses the heat exchanging device 140 to then be brought securely into contact with the surface of the CPU 28. Thus, the bottom plate 134 of the heat exchanging device 140 can be more securely in contact with the surface of the CPU 28.

Rotation preventing grooves 144 and rotation preventing ribs 167 are provided for preventing the heat exchanging device 140 from rotating when the fastening thread 166 is fastened. The rotation preventing grooves 144 are vertically formed on at least one of four lateral surfaces of the cooling plate 131, preferably, one on each lateral surface of the cooling plate 131. The rotation preventing ribs 167 are provided on the compression plate 160 to be disposed at locations corresponding to the rotation preventing grooves 144. The rotation preventing ribs 167 protrude downward from the compression plate 160 so as to be fitted into the rotation preventing grooves 144 when the compression plate 160 is installed in the heat exchanging device 140.

The means illustrated in FIGS. 15, 16A and 16B can be used for securely contacting the heat exchanging device shown in FIG. 11 with a slot type CPU. As shown, a slot type CPU 28' includes an outer plate 29 made of aluminum and a plurality of first through holes 181 are formed on the outer plate 29. The securely contacting means for use in the CPU 28' includes fasteners 177 for pressing the compression plate 170 installed to be in contact with the surface of the cooling plate 131 and the heat exchanging device 140.

A rectangular opening 172 is formed in the central portion of the compression plate 170. The opening 172 allows the compression plate 170 to be installed on the heat exchanging device 140 without being interfered by the inlet port 138 and the outlet port 139. Also, a protruding surface 146 protruding a predetermined height, preferably equal to the thickness of the compression plate 170, is provided on the cooling plate 131. The shape and size of the protruding 146 are determined so as to be fitted into the opening 172 when the compression plate 170 is combined with

the heat exchanging device 140. Thus, when the heat exchanging device 140 and the compression plate 170 are installed in the CPU 28', the heat exchanging device 140 is not moved separately from the compression plate 170, thereby facilitating the installation. Such configuration is advantageously used for installing the heat exchanging device 140 on the lateral side of the CPU 28' which is disposed upright.

A plurality of second through holes 176 corresponding to the first through holes 181 are provided at four edges of the compression plate 170. The fasteners 177 are inserted into the first through holes 181 and also inserted into the second through holes 176 corresponding to the first through holes 181. One end 178 of each fastener 177 is crooked so as to be locked with the inner surface of the outer plate 29 of the CPU 28', and each tightening nut 180 is engaged with the other end 179 of the fastener 177. If the tightening nut 180 is tightened, the compression plate 170 presses the top surface of the cooling plate 131 to bring the bottom plate 134 securely into contact with the surface of the CPU 28', that is, the outer surface of the outer plate 29. Thus, the bottom plate 134 of the heat exchanging device 140 can be more securely in contact with the surface of the CPU 28'.

FIGS. 17 and 18 illustrate preferred embodiments of a heat exchanging device 190 for use in a memory. As shown, the heat exchanging device 190 includes a first cooling plate 191 and a second cooling plate 192 in heat exchangeably contact with both sides of a memory 32. At least two first connecting projections 194 are provided lengthwise on the inner surface of the first cooling plate 191, that is, on the surface facing the second cooling plate 192 and are spaced a predetermined distance apart from each other. The first connecting projections 194 have first conduit insertion holes 195 piercing lengthwise so that a conduit 198 having a long rod shape is inserted there through. Also, second connecting projections 194' inserted between the first connecting projections 194 to then be engaged, are provided on the inner surface of the second cooling plate 192, that is, on the surface facing the first cooling plate 191. The second connecting projections 194' also have second conduit insertion holes 195' piercing lengthwise so that the conduit 198 is inserted there through. In a state in which the first cooling plate 191 is combined with the second cooling plate 192 so that the first connecting projections 194 and the second connecting projections 194' are engaged, the conduit 198 is inserted into the first and second conduit insertion holes 195 and 195'. Here, a torsion spring 197 is fitted along the periphery of the conduit 198. The torsion

spring 197 is interposed between the first cooling plate 191 and the second cooling plate 192 to apply elastic force thereto so that the inner surface of each of the first and second cooling plates 191 and 192 is brought securely into contact with both sides of the memory 32.

A heat bond is interposed between the inner surface of the first conduit insertion hole 195 piercing in the first connecting projections 194 and the outer surface of the conduit 198 so that the conduit 198 is fixed to the first cooling plate 191. However, the second cooling plate 192 can rotate freely about the conduit 198. Thus, while preventing the first and second cooling plates 191 and 192 from moving lengthwise with respect to the conduit 198, the action of the torsion spring 197 is not interfered.

The opposite ends of the conduit 198 form an inlet port 199 and an outlet port 200 through which the liquid coolant comes in and goes out. Thus, the conduit 198 functions as the liquid coolant circulating passageway of the heat exchanging device 190 according to this embodiment. The heat generated from the memory 32 is transferred to the first and second cooling plates 191 and 192 and then transferred to the liquid coolant flowing through the conduit 198, thereby cooling the memory 32. The above-described heat exchanging device 190 in which the liquid coolant circulation path is positioned at the upper portion of the memory 32, is particularly useful in the case where the distance between each of a plurality of neighboring memories 32 is small.

FIGS. 19 and 20 show two industrial computers 110 and 110' each having cooling apparatus according to the present invention incorporated therein. Referring to FIG. 19, the industrial computer 110 has a rack mount case 112. Inlet vents 114 are formed on one side wall of the rack mount case 112. Outlet vents are formed on the other side wall of the rack mount case 112 to be spaced a predetermined distance apart from the inlet vents 114. The two side walls may meet at an angle and may be perpendicular to each other. The opposite ends of the heat dissipation device 36 are positioned adjacent to the inlet vents 114 and the outlet vents, respectively. The positioning of the inlet vents 114 and the outlet vents allows ambient air to flow freely through the heat dissipation device 36 without interference from vertically adjacent cases of computers mounted on the same rack. As shown, a fan 116 is positioned adjacent to the outlet vents opposite to the inlet vents 114. Alternatively, the fan 116 itself may form outlet vents. A separating wall

118 is installed inside the case 112, and the separating wall 118 isolates components of the industrial computer 110 from the flow of ambient air passing through the heat dissipation device 36. Thus, even if the industrial computer 110 is used under inferior circumstances, external air is not induced to the components, thereby preventing the components from being contaminated due to foreign matter such as dust.

FIG. 20 is similar to FIG. 19 but shows a different type of rack mount industrial computer 110'. The computer 110' has a rack mount case 112'. In the industrial computer 110', inlet vents 114' and the fan 116 are located at opposite side walls of the case 112' rather than intersecting side walls shown in FIG. 19. Opposite separating walls 118' isolate components of the computer 110' from the flow of ambient air passing through the heat dissipation device 36. In FIGS. 19 and 20, radiating fins are preferably oriented horizontally, rather than vertically as in FIG. 4A. Arrows shown in FIGS. 19 and 20 indicate the directions of the flow of ambient air passing through the heat dissipation device 36.

FIG. 21 is a partly cut-away perspective view of a personal computer having a cooling apparatus according to still another embodiment of the present invention and FIG. 22 is a schematic diagram of the structure of the cooling apparatus installed in the personal computer shown in FIG. 21.

Referring to FIGS. 21 and 22, a reservoir 638 is installed inside a tower case 604 separately from a heat dissipation device 636, an increased pressure of water can be formed at normal times, and an induction pump 652 and a discharge pump 654 are separately provided to allow a pumping operation even if malfunction occurs to either part.

Also, the tower case 604 has a heat dissipation device 636 installed in the place of a conventional CD-ROM upward with respect to the tower case 604, and an upper housing 614 having an air inlet opening 618 and an air outlet opening 620.

In the upper housing 614, a separation wall 612 is installed between the heat dissipation device 636 and the heat-producing components in order to protect the components installed inside the interior space from being contaminated due to foreign matter such as dust.

In particular, the upper housing 614 includes each two pairs of air inlet openings 618a and 618b and air outlet openings 620a and 620b so that some of air passed through one air inlet opening 618b is exhausted to the air outlet openings

620b by the heat dissipation device 636, e.g., a Louver fin cooler, and the other of air passed through the other air inlet opening 618a is exhausted the air outlet openings 620b through a power supply 622 by the heat dissipation device 636. A fan 650 for forcibly causing the flow of air is provided in each of the air inlet openings 618a and 618b and the air outlet openings 620a and 620b.

Here, the air exhausted by the power supply 622 can be applied to the fan 650 installed in the conventional power supply 622.

Thus, according to another embodiment of the present invention, a heat exchanging device having a passageway extending between an inlet port and an outlet port is installed in each heat-producing component. The passageway heat-exchangeably contacts with the heat-producing components, so that liquid coolant C circulates through the passageway in order to carry heat away from the components.

In other words, the coolant C stored in the reservoir 638 is induced by the discharge pump 654 and circulates consecutively through the second conduit 648, the memory 32, the microprocessor chip 30 and the heat exchanging devices of the CPU. Subsequently, the coolant C is cooled while passing through the heat dissipation device 636, passes through the first conduit 646 and circulates back to the reservoir 638 through the induction pump 652. Small arrows shown in FIG. 22 indicate circulation paths of the coolant C.

The circulation paths of the coolant C may be disposed in a direction opposite to that described above. Also, the inlet and discharge pumps may be disposed in the first and second conduits.

Thus, the coolant C can form an increased pressure of water by a difference in the pressure of liquid formed by the discharge pump 654 and the induction pump 652. Also, a pumping operation can be performed even if malfunction occurs to either part, thereby preventing deterioration of a computer.

The tower case 604 has a heat dissipation device 636 installed in the place of a conventional CD-ROM upward with respect to the tower case 604 to be easily adopted to the conventional tower case. Also, the air inlet opening 618 is separately provided. Some of the air having passed through the air inlet openings 618a and 618b is exhausted to the heat dissipation device 636 and the other air is exhausted to the power supply 622. Thus, the fan 650 of the conventional power supply 622 can be utilized as it is. The fan 650 is installed at each of the air inlet

opening 618 and the air outlet opening 620, thereby maximizing the heat dissipation efficiency.

In other words, in order to maximize heat dissipation, one side air is induced from the upper portion of the tower case 604 to then be exhausted upward and the other side air is induced from the upper portion of the tower case 604 to then be exhausted rearward.

The fan 650 has a separate controller (not shown) to adjust the number of revolutions of the fan 650 according to the ambient circumstances, that is, into a quite mode, a medium mode and a max mode.

The adjustment of the number of revolutions of the fan 650 is done manually according to user's switching or automatically according to the temperature set by a user.

A safety valve 655 for exhausting gas outside during dilation of the internal pressure of the reservoir 638 and adjusting the pressure, is installed at an upper end of the reservoir 638.

Thus, the gas generated due to erosion or an increase in temperature of conduits or reservoir can be exhausted outside.

As shown in FIG. 22, a coolant entrance 657 which can be opened or closed by a screw or cork is formed at the topmost end of the passageway, that is at an upper end of the heat dissipation device 636, so as to facilitate refilling or discharge of the liquid coolant C. Also, a large coolant entrance 657 which can be opened or closed by a screw or cork is formed at the lowermost end of the passageway, that is at a bottom of the reservoir 638, so as to facilitate refilling or discharge of the liquid coolant C.

Thus, when old and useless coolant C is discharged, the coolant entrances 657 are both opened so that the coolant C can be fast discharged to the reservoir 638. In order to refill new coolant, the coolant entrance 657 provided at the upper end of the heat dissipation device 636 is closed, the computer is overturned so that the bottom of the reservoir 638 faces upward, and a large amount of liquid coolant C can be injected into the reservoir 638 through the coolant entrance 657 provided at the bottom of the reservoir 638.

At normal times, liquid coolant C can be refilled little by little through the coolant entrance 657 formed at the upper end of the heat dissipation device 636.

The reservoir 638 is formed of a transparent material so as to allow a user to

check the amount of liquid coolant C stored therein and may be provided with an alarm device of warning the time of refilling of the coolant C so as to inform the user of the shortage of the coolant.

Additionally, in the event that cooling is not performed properly due to several causes in the cooling system, resulting in an abnormal increase in the temperature of the computer, there may be provided a controller for detecting abnormality by means of a sensor, notifying a user of the abnormality through lighting or alarming, and automatically interrupting the operation of the computer in a predetermined time, e.g., in approximately 2 minutes if the user takes proper steps.

The power for the induction pump 652 and the discharge pump 654 can be supplied from the power supply 622 without using a separate power supply for pumping, thereby reducing the cost, prolonging the life span of the product and satisfying the power/frequency standards.

An inverter having a converter for converting the conventional DC supplied from the power supply 622 into an easily driven AC may be further provided.

FIG. 23 is a fragmentary perspective view of a personal computer having a cooling apparatus according to still another embodiment of the present invention.

Referring to FIG. 23, a heat dissipation device 736 is installed upright at one side wall of a tower case 604, an air inlet opening 718 is formed at a position next to the lower side wall of the heat dissipation device 736, and an air outlet opening 720 has a side housing 714 having a separation wall 712 so as to utilize the air outlet opening 720 having a fan 750 of the conventional power supply 722.

Also, the side housing 714 includes an intermediate fan 721 having a duct 719 for forcibly inducing the air having passed through the air inlet opening 718 to be guided to the power supply 722.

Thus, as indicated by arrows shown in FIG. 23, the air passes through the air inlet opening 718 formed at the lower portion of the tower case 704 and rises along the separation wall 712 to reach the intermediate fan 721 via the heat dissipation device 736. Then, the air forcibly passes through the power supply 722 by means of the intermediate fan 721 to then be exhausted to the air outlet opening 720 by means of the fan 750 of the power supply 722.

Although the preferred embodiments of the invention have been illustrated and described herein, it is intended to be understood by those skilled in the art that various modifications and omissions in form and detail may be made without

departing from the spirit and scope of the invention as defined by the appended claims.

As described above, according to the present invention, since heat-producing components are cooled by a liquid coolant circulating through a heat exchanging device installed to be securely in contact with the heat-producing components, the cooling capacity is enhanced compared to the conventional air cooling system. Also, since the flow of ambient air for cooling the warmed liquid coolant is isolated from the heat-producing components, internal contamination of a computer due to induction of dust can be prevented. Thus, the life span of a high-priced computer can be prolonged even under inferior circumstances and the defects thereof can be reduced. Also, in the case where the flow of ambient air is produced by natural convection, the noise due to use of a fan is not generated. In the case of using a fan, the fan is operated at a level of 70% rated power to prolong the life span of the fan and reduce the noise generated by the operation of the fan, thereby making agreeable working circumstances.